5. Storage Lagoons

Needs to Know Criteria
▪ Role of short-circuiting
▪ Causes and corrective actions for algae growth and odor production, short-circuiting, anaerobic conditions, vector control, and excessive coliform levels
▪ Lagoon maintenance procedures
▪ Importance of freeboard
▪ What to do if minimum freeboard is exceeded
▪ Lagoon wildlife or rodent maintenance problems
▪ Posting and maintaining warning signs around a wastewater storage lagoon
▪ Frequency of seepage testing a wastewater land application storage lagoon

Because no land application system can operate continuously, a lagoon can provide wastewater storage when tank storage is unrealistic, for example, during winter months or during maintenance. Although a limited amount of treatment may occur in storage lagoons, they are designed primarily for storage. This section primarily addresses the role of storage lagoons at land application sites. Treatment lagoons are covered as part of your wastewater treatment operator certification obtained previously.

Lagoon Design and Configuration

Lagoons are generally designed and constructed with earthen dams or dikes. The inner dikes of new lagoons are typically lined with a synthetic material to prevent leakage. Figure 5-1 shows a typical lagoon design. To allow mowing of the outer banks, outside slopes are usually no more than 3 units horizontal to 1 unit vertical for slope stability and maintenance. Lagoons must be designed for a minimum *freeboard* (the distance between the top of the dike at its lowest point and the highest allowed wastewater level within the lagoon). This provides a safty factor for wave action, higher than planned wastewater generation rates, or heavy precipitation events. For existing lagoons utilizing clay or earthen liners or lagoons that have a buried sysnthetic liner, the inside slopes may be protected by riprap from 1 foot below the minimum water surface to the top of the freeboard to protect against wave erosion.

Design requirements for new lagoons are meant to minimize seepage losses of the stored effluent. New installations typically used HDPE (high density polyethylene) or buried PVC (poly vinyl chloride) liners. DEQ permits typically require periodic seepage rate testing to evaluate liner intergrity. Lagoon seepage above DEQ performance criteria generally requires the repair, replacement, or abandonment of the lagoon.

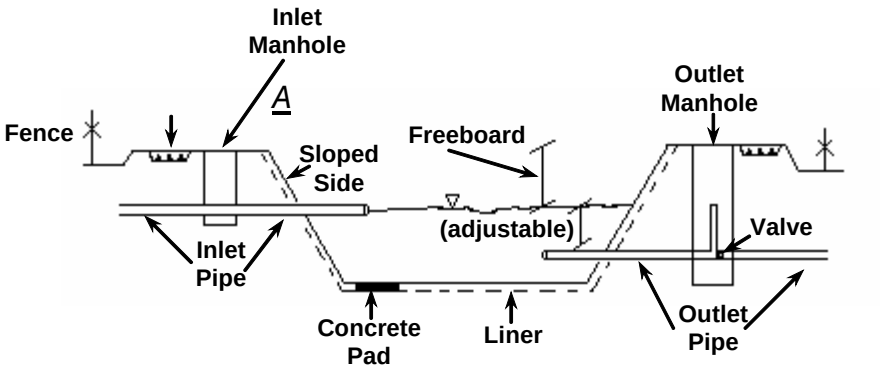

Figure 5-1. Typical lagoon design. [From Wastewater Stabilization Ponds, 1981]

Liners are used to minimize the loss of wastewater to the subsurface or ground water by reducing the permeability of the bottom and sidewalls of lagoons. The typical materials used for liners are synthetic membranes, compacted clay, and bentonite. As discussed previously, for new storage ponds, synthetic membrane liners are generally used. Clay and bentonite liners require submergence in water to retain their sealing characteristics. If exposed and dried, clay and bentonite liners may develop cracks and lose their ability to provide a good seal.

Wastewater land application facilities perform seepage rate tests to demonstrate the integrity of their lagoons. DEQ recommends that current seepage data be submitted as part of the permit renewal application package each five years. Results of the seepage test will determine any permit conditions needed to update or modify the lagoons.

Wastewater enters and leaves a lagoon through inlet and outlet pipes. Inlet structures should be located so that wastewater is distributed evenly in the pond. If wastewater is gravity fed to the lagoon, a concrete pad or riprap is often placed at the end of the inlet pipe to protect the lagoon liner. If the lagoon is used for chlorine treatment, the outlet pipe is located as far as possible from the inlet pipe to increase chlorine detention time and to prevent *short-circuiting* (a condition where some of the wastewater in a lagoon travels faster than the rest of the wastewater, between the inlet and outlet pipes). Short-circuiting is especially a problem in lagoons that are designed to allow for a specific *chlorine contact time* (the amount of time chlorine must be allowed to react with the wastewater prior to discharge and reuse).

The following are some of the some factors used to determine the volume of lagoon storage capacity that is required:

1. If the land application system is designed for growing season only application, the lagoon(s) is designed for storage of effluent throughout the non-growing season.

2. If the land application system is designed with a non-growing season application allowance, storage may be necessary for periods of extreme cold temperatures which can prevent application due to freezing problems in the irrigation system, frozen soils, or buildup of ice on the application site.

3. If land application is not possible due to harvesting or heavy precipitation events.

Other design considerations for storage lagoons include:

- Multiple cells will provide access for maintenance.
- Proximity to surface waters and well used for drinking water.
- If odors are a potential concern, site the lagoon to minimize impacts.

If odors are a potential concern, aeration can reduce odor causing conditons.

5.2 Lagoon Operation and Maintenance

Regardless of how well-designed, lagoons will not perform to their optimum potential unless properly operated and maintained. Inspections and sampling should be conducted on a routine basis to determine if any problems are apparent.Routine operation and maintenance practices should address and control the following conditions and situations:

- emergent (rooted) plants
- suspended vegetation
- erosion
- excessive algae
- odor production
- insufficient freeboard
- short-circuiting, if chlorine treatment is a component of the storage lagoon

In addition, basic management steps, such as posting and maintaining warning signs around a wastewater storage lagoon, can improve site safety and minimize public health impacts. Fencing should be provided to discourage unauthorized access and prevent wildlife access.

Vegetation

Controlling vegetation around storage lagoons is very important. Weeds and grasses on dams and dikes provide sheltered areas for insects and burrowing animals, interfere with the establishment and maintenance of a desirable vegetative cover, and hinder visual inspection of dikes. Trees and other deep-rooting vegetation can impair the structural integrity of lagoon dikes. Regular mowing and weeding are required to avoid these problems.

Emergent and suspended vegetation in lagoons takes up valuable space, provides a breeding ground for potential vectors, such as mosquitoes, and hinders pond circulation. In addition, dead vegetation can contribute to BOD levels and cause odors.

Emergent growth will occur when sunlight is able to reach the lagoon bottom in older lagoons with earthen bottoms or lagoons with a buried synthetic liner. Emergent growth can be controlled by the following:

- immediate removal of young plants (including roots)

- drowning weeds by raising the water level and preventing sunlight from reaching the plants
- by installing pond liners
- as a last resort, using herbicides (which should only be used with the approval of the Department of Environmental Quality) and taking into consideration impacts to the land application fields

Suspended vegetation, such as duckweed and algae can occur in any lagoon, regardless of depth. Often mistaken for algae, duckweed floats on a lagoon surface and has long hair-like roots that hang down into the water. It grows rapidly and can cover the entire surface of a lagoon if not controlled. If suspended vegetation is a problem, it should be skimmed off with rakes or other tools or mechanically harvested. As a last resort, a herbicide can be used by using the precautions outlined above. If not removed, vegetation may cause plugging in the irrigation system..

Ducks eat duckweed (hence, the name) and may control a light growth of suspended vegetation. Fecal waste from ducks and other waterfowl, however, can contribute BOD to the lagoon and increase coliform levels. Depending on the required disinfection level of the effluent, the attraction of waterfowl to a storage lagoon may seriously impact the effluent quality. Disinfection downstream of the storage pond may be necessary in some cases to achieve required effluent quality levels.

Erosion

Erosion can wash away clay liner material on inside banks or create cracks and crevices in outer banks. Both situations reduce the structural integrity of lagoon dikes and can result in leaks and dike failure. Erosion can be caused by wave action, surface runoff from precipitation, or holes dug by burrowing animals, lack of proper vegetation on outside slopes, steep slopes, or poor maintenance..

Installing riprap or broken concrete along banks and dikes can minimize erosion and limit weed growth. However, this practice cannot be used for exposed synthetic liners.

Diversion ditches and proper grading around the lagoon may be used to divert surface water away from the lagoon. Burrowing animals, such as gophers, moles, ground squirrels, and groundhogs, should be trapped and removed.Burrowed holes should be repaired immediately to prevent erosion.

Excessive Algae

Excessive algae growth can create serious problems. Algae blooms die off as suddenly as they appear, blocking sunlight and the dead vegetation can cause foul odors. The die-off of algae blooms also causes a very high BOD loading which reduces dissolved oxygen levels, andthe lagoon may become anaerobic or septic and cause odor problems.

A specific type of algae that can be problematic is blue-green algae. A bloom (rapid growth) of blue-green algae can be caused by organic overloading, nutrient overloading, high water temperatures, or stagnant conditions.

Blue-green algae are bacteria that grow in fresh water lakes, ponds and wetlands, as well as wastewater storage lagoons. They are photosynthetic bacteria, and their scientific name is Cyanobacteria. They usually occur only in small numbers and are so small they are invisible to the casual observer.

When a bloom occurs, huge numbers of algae grow and accumulate on the surface of the lagoon, to the point where the surface of the water resembles thick "pea soup." often blue-green in color. Although these blooms occur naturally, water bodies which have been enriched with plant nutrients from municipal, industrial or agricultural sources are particularly susceptible to these growths.

Blue green algae blooms are unsightly, but more important, blue-green algal blooms can be toxic if ingested by wildlife, livestock, or people. Blue green algae produce neurotoxins, which affect the nervous and respiratory systems and hepato-toxins, which affect the liver function.

If blue-green algal blooms are suspected, they should be treated with caution. One of the first signs of toxin contamination in a water body is the presence of stressed, sick or dead wildlife or waterfowl. Contact DEQ or your local District Health Department if you suspect a problem. Water suspected of being contaminated with toxic strains of blue-green algae can be sampled and tested for toxicity.

Algae mats should be broken up and dispersed or physically removed like duckweed.

Algae can also be controlled by physical, chemical, and biological means:

- Lagoon covers (artificial or natural) eliminate sunlight, photosynthesis, and vegetative growth.
- Aeration or mixing removes carbon dioxide from the water and reduces plant growth.
- Shock chlorination at high doses for short duration and at a lower chlorine dose for longer duration have both been used successfully in controlling algae.
- Copper sulfate is the most common chemical used to control algae.
- Non-toxic dyes to reduce sunlight penetration in the water.

Note: When considering any chemical or biological means of algae control, an operator must make sure that the action is approved by the Idaho Department of Environmental Quality (DEQ) and is not a violation of permit conditions.

Odor Prevention

Some storage lagoons can produce odors from time to time, depending on the water quality of the stored wastewater and how the ponds are maintained and operated. If odor are a problem or anticipated to be a problem, an odor management plan must be submitted to and approved by DEQ.

The Odor Management Plan should cover wastewater treatment systems, land application facilities, storage lagoons, and other operations associated with the facility. The plan should include specific design considerations, operation and

maintenance procedures, and management practices to be employed to minimize the potential for or limit odors. The plan should also include procedures to respond to an odor incident if one occurs.

Odors related to storage lagoons may be caused by the following:

- Storage of wastewater with a high organic content
- Stagnant conditions or long detention times of water in storage
- Lagoon turnover due to seasonal temperature changes. This causes a vertical movement of the lagoon contents causing the lower anaerobic zone to move towards the surface
- Accumulation of dead vegetation or algae in the lagoon

Most odors in the lagoon water column are caused due to anaerobic conditions which generate odorous gases such as hydrogen sulfide and mercapans.

Insufficient Freeboard

A properly designed storage lagoon system will provide adequate freeboard or safety volume to prevent an overflow from the lagoon. Overflow from lagoons, for any reason, is a violation of state rules and is subject to enforcement action. Allowing a lagoon to reach its maximum storage capacity before the start of the non-growing season does not leave room for storing excess precipitation during extended wet periods. In the late summer/early fall, lagoons are typically pumped down as far as possible.

In Idaho, storage lagoons are designed to have a minimum of two feet of permanent freeboard. Under normal operations, the freeboard space will not be used for water storage. However, under some conditions, the freeboard space may be encroached upon:

- Extremely high precipitation event.
- High wastewater generation rates due to rapid population growth, inflow/ infiltration problems, or in industrial systems, plant upsets or unusual operations resulting in greater generaton of wastewater.
- Inability to lower storage lagoon volume to minimum levels prior to the winter storage season.

If a situation arises that could result in approaching a lagoon overflow, contact your regional DEQ office to evaluate the situation and to determine what actions and approvals may be needed.

Short-Circuiting

Short-circuiting is a condition that occurs when some of the wastewater in a lagoon or basin travels faster than the rest of the flowing water, typically between the inlet and outlet pipes. This problem can be caused by such factors as poor design, sludge accumulation in the lagoon bottom, vegetation that hinders lagoon circulation, and temperature gradients in the water column.

Short circuiting is a bigger concern for lagoons that perform treatment or are used for chlorine disinfection. It is of less of a concern for lagoons used solely for storage. However, if the short circuiting causes stagnant conditions in a portion of the lagoon, it can cause odor problems depending on the water quality.Short-circuiting can be verified by the use of dye tests and may be corrected or prevented by using curtains or baffles to redirect flow, relocatiing inlet and outlet pipes, controlling vegetation, and removing excessive sludge deposits from the lagoon.

References:

State of North Carolina, 2001. Spray Irrigation System Operators Training Manual.

State of Idaho, Department of Environmental Quality, 2005. Wastewater Land Application Permit Rules (IDAPA 58.01.17).

State of Idaho, Department of Environmental Quality. Guidance for Land Application of Municipal and Industrial Wastewater - October 2004

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